SCHOOL OF CIVIL ENGINEERING

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JOINT HIGHWAY RESEARCH PROJECT

JHRP-87-3

Interim Report

EVALUATION OF THE COORDINATION OF WEIGH-IN-MOTION TRUCK DATA IN INDIANA

John D.N. Riverson
Kumares C. Sinha

PURDUE UNIVERSITY

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TO: H. L. Michael, Director
Joint Highway Research Project

June 5, 1987

FROM: K. C. Sinha, Research Engineer
Joint Highway Research Project

FY86 RTAP FHWA WIM Project
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Attached is an interim report on the FY86 RTAP WIM Project entitled, "Evaluation of the Coordination of Weigh-in-Motion Truck Data in Indiana." This project is funded by the FHWA and is being conducted in cooperation with the Indiana Department of Highways (IDOH) in connection with the HPR study on WIM Data Collection undertaken by the IDOH. This report covers Tasks 1, 2 and parts of Task 3. The study was done by Dr. John D. N. Riverson under my direction.

This report is forwarded for review, comment and acceptance by the IDOH and FHWA as fulfillment of the objective of the study.

Respectfully submitted,

KCSinha

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16. Abstract

The report presents the results of a survey of transportation related agencies in Indiana to determine their need for truck traffic and truck weight data. Objectives for a WIM program in Indiana are defined as a basis for coordination of WIM data. Alternative arrangements for administering WIM data collection are reviewed. Current monitoring locations for the traffic volumes and vehicle speeds are compared with those selected for the WIM Pilot Study by the Division of Research and Training of IDOH and matching locations are presented in a map. The potential for consolidating data collection by two or more systems at locations with common data types is discussed.

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EVALUATION OF THE COORDINATION OF WEIGH-IN-MOTION TRUCK DATA IN INDIANA

(FY86 RTAP WIM Project)

Interim Report

by

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Prepared as Part of an Investigation

Conducted by

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Indiana Department of Highways

and the

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FHWA RTAP WIM COORDINATION STUDY

Interim Report

Introduction

Indiana is a cross-road state lying at the junction of major east-west and north-south interstate routes. Indiana is also one of ten states with the largest truck registrations in the country. Systematic information on truck weight distribution on Indiana highways, however, has been lacking. Indiana was among the first states that became interested in Weigh-in-Motion (WIM) in its early stages. In 1978 WIM was installed as a screening device at a permanent weigh station following a decision made early in 1975. In spite of disappointing performance of the original WIM equipment, the interest in WIM has continued. The idea of using WIM for weight measurements was rekindled in 1985 when a HPR study entitled "Pilot Study of a Portable High Speed Weigh-in-Motion System" was initiated by the Division of Research and Training (DRT) of Indiana Department of Highways (IDOH). In addition to this study, an FHWA FY86 RTAP study entitled "Evaluation of Coordination of WIM Data" was started in 1986 and undertaken by Purdue University through the Joint Highway Research Project (JHRP) in cooperation with IDOH and the Indiana State Police.

Study Objectives and Major Work Elements

The major objective of the RTAP WIM Coordination Study is to review practices and needs of transportation and other agencies in Indiana regarding the use of truck weight and traffic data as well as the appropriate organization for program administration, field operation and equipment support for WIM data collection and analysis.

The above objective is being accomplished through the following major tasks:

1. Review current and planned activities of states using WIM data.

2. Identify all possible users of WIM data including the types of information desired or used now.

3. Identify elements of WIM program administration, field operation, equipment support and WIM data sharing in Indiana.

4. Develop alternative methods of coordination and evaluate their effectiveness.

5. Select the desirable method of coordination for implementation and document the findings for national distribution.

The first two tasks and some aspects of Task 3 have been completed and are reported in this interim report. Parts of Task 3 as well as Tasks 4 and 5, depend on the progress made in the pilot project being undertaken by the DRT. The pilot project, among other activities, is investigating WIM data collection methods at selected locations using a portable WIM scale.

This interim report presents a review of WIM practices in other states and the results of a survey of the truck weight data requirements of various transportation related agencies or organizational units in Indiana. Information collected from the two IDOH divisions - Program Development and Research and Training - regarding their programs for traffic and WIM data collection is also discussed.

Summary of WIM Experience in Other States

The NCHRP has recently published a Synthesis [1] on the use of WIM systems for data collection and enforcement. WIM technology has been tested and used in Canada, in the UK by the Transport and Road Research Laboratory, as well as in France and other European countries and South Africa. In the U. S., 42 states including Indiana, have used seven different WIM systems (Table 1). The WIM system originally used by Indiana for screening at permanent static weigh stations, was manufactured by Streeter Richardson. Three

Table 1. Summary of States' Experiences with Various WIM Equipment.

WIM Type	Number of States Using Equipment [2]	Types of Use [1]	Special Characteristics and Advantages and Disadvantages [1]
Bridge WIM	11	1. Planning 2. Target Enforcement 3. Special Studies 4. Cost Allocation 5. ESAL Determination	1. Small crew (2) required for installation 2. Extensive rehabilition of road approach may not alvoys be required. 3. Multi-vehicle bridge load information can be obtained 4. Flexible and portable system 5. More data can be collected in less time than with a static scale. 6. System is usually undetectable by drivers 7. Requires a suitable bridge before data collection can be possible. 8. A maximum of 85 ft single span or a series of non-continuous spans are required. 9. Difficult to isolate individual truck data in high volume traffic. 10. Accuracy may be inadequate for enforcement 11. Data reliability decreases with angle of bridge skew 12. Center lane is difficult to monitor on 3-lane highways
Radian	13 (3) [3]	1. Collection of TWS data	1. Data can be obtained from 4 lanes at a time 2. Equipment has been durable and reliable over a long period of time 3. Bridge formula compliance is determined
IRD	4	1. Truck weight monitoring 2. Medium speed IRD used as a vehicle sorter before static weighing.	1. Continuous operation even in extremely cold temperature. 2. Multilane monitoring is possible 3. System has been interfaced with AVI in Oregon.

1. Summarized from NCHRP Synthesis No. 124 [1].
2. Some States have used more than one equipment type at a time
3. Numbers in parenthesis show number of states out of the total recorded that have removed their equipment.

Table 1. Continued.

WIM Type	Number of States Using Equipment [2]	Types of Use [1]	Special Characteristics and Advantages and Disadvantages [1]
Siemens-Allis (PAT)	8 (1) [3]	1. Planning and Design 2. Enforcement Sorting	1. Multilane monitoring 2. Weight transducers must cover entire entire lane width to avoid straddling 3. Accuracy criteria may vary according to need and criticality 4. Problems have been experienced with electronic component failure and with grouting for frames 5. Longitudinal grades caused braking and acceleration which affected accuracy. 6. Weighmats installed flush with the ground can be used when ice and/or snow are on the road.
Streeter Richardson	12	1. Enforcement screening 2. Truck Weight Study 3. Remote monitoring	1. Best to install in concrete and provide lightning protection. 2. Operable in several modes, automatic polling and telemetry, TWS, selective weight enforcement, remote monitoring, and diagnostic and initial set up 3. Used for vehicle sorting
Golden River	5	1. Truck weight monitoring	1. Can be st up by crew of 2 in less than 1 hour and can be operated unattended. 2. Measurements were sometimes influenced by speed, ambient temperature, axle weight and site selection 3. Sites should be level with smooth approaches and not subjected to heavy braking.
Weighwrite	2 (1) [3]	No information available	No information available

1. Summarized from NCHRP Synthesis No. 124 [1].
2. Some States have used more than one equipment type at a time
3. Numbers in parenthesis show number of states out of the total recorded that have removed their equipment.

states have used at most three WIM equipment types, eight states have used two types and the rest used only one type of WIM equipment at any time. Table 1 presents general characteristics of the seven WIM types including some advantages and disadvantages mentioned by the states that have used them.

The experiences of the states using WIM have been varied and generally the type of problems experienced have differed depending on the type of equipment used. The NCHRP Synthesis [1] describes some experiences of individual states using each of the specific equipment types that have been summarized in Table 1. The Bridge WIM (BWIM) system is the only one that is not installed on highway pavements directly. It has been found to be undetectable, accurate and flexible to use by most states using them. The system is generally portable as long as suitable bridge structures are available for installation [1]. It is a useful technology for monitoring truck weights on highways other than Interstates. The BWIM option was not, however, initially selected by the IDOH. The DRT (IDOH) is currently using a portable Golden River Weighman equipment in its pilot studies.

WIM Systems Accuracy

A major consideration regarding the use of WIM for purposes including enforcement is the level of accuracy of the weight measurement. The Bureau of Standards stipulates that a wheel load weigher should have an accuracy of ± 1% when tested for certification and thereafter maintained at ± 2% [1,2]. Studies by Lee [1,3] showed that the accuracy of WIM systems that measure dynamic loads is affected by roadway, vehicular and environmental factors. Roadway factors can be controlled during site selection while environmental factors can be controlled through careful scheduling but vehicular factors, especially tire condition, are difficult to control. Suitable levels of acceptable accuracy, especially for higher speed WIM operation, need to be established. If the measured weights are to be used to determine proportion of trucks that are overweight, or violators of weight limit regulations, suitable dynamic weight limits should be established to enable appropriate enforcement measures to be taken. Otherwise, WIM technology should be used, at least now, to determine truck weight distribution for planning, pavement design and pavement management purposes only. Once the levels of accuracy have been established, the information can also be used for highway cost allocation purposes. For Indiana, the accuracy of the portable WIM equipment is being determined as part of a pilot study undertaken as a HPR project.

Survey of Data Needs of Organizational Units in Indiana

Sixteen organizational units including individual agencies and IDOH divisions were interviewed. Appendix A presents a list of the organizational units that were contacted as well as a summary of their individual requirements for truck weight and other traffic data. Other agencies such as County Highway Departments were not included in the survey. Nevertheless, their specific data needs would be similar to the requirements identified for some of the major users included in the survey. Although County Highway Departments usually plan their highway network separately from the IDOH, selected county highway locations could be included in the IDOH WIM monitoring programs to cater for general county highway planning needs. Tables 2 to 5 present summary information on the frequency of truck weight data use, data used or needed, purpose for which truck weight data is used and suggested locations for which WIM data collection would be desired. Table 4 shows that truck traffic and weight data are currently used or desired by 1 out of the 15 organizational units interviewed. A representative of the Indiana Motor Truck Association (IMTA) was interviewed in addition to the above but the comments concerned mainly enforcement and they are included in the section on enforcement later.

Table 2. Frequency of Truck Weight Data Use by Various Organizational Units in Indiana

Frequency of Use	Number of Org. Units*
1. Routinely	4
2. Used As Needed	5
3. Not used now but data can be useful	4
4. Not used at all	2

* Total Number of Organizational Units interviewed was 15.

Table 3. Trucks and Truck Weight Information Used or Desired.

Type of Information	Number of Org. Units	Percent of Total
1. Vehicle/Truck Volumes (Vehicle Classification Counts)	11	73
2. Gross Vehicle Weight	7	47
3. Axle Weight Distribution	5	33
4. Number of Axles	4	27
5. Annual Truck Weight Trends	4	27
6. Axle Spacing	2	13
7. Axle Weights by Highways Lanes	2	13
8. Percent of Trucks Overweight	1	7
9. Truck Volumes Bypassing Weigh Stations	1	7
10. Axle Weight Distribution by Vehicle Type and Highway Functional Class	1	7
11. Passenger Car Equivalence of Trucks	1	7
12. Vehicle Speed	1	7
13. Time of Passage	1	7
14. Truck Lengths	1	7
15. Unladen Truck Weight	1	7
16. Purchase Date/Price	1	7
17. Bridge Formula Compliance	1	7
18. Commodity Flow Characteristics	3	20

Table 4. Purpose of Truck Information Use.

Purpose	Number of Org. Units	Percent of Total
1. Traffic Characteristics and Growth Factors	8	53
2. Traffic Safety	5	33
3. Pavement Design	4	27
4. Pavement Management	4	27
5. Revenue Estimation	4	27
6. Bridge Design	3	20
7. Traffic Regulations	3	20
8. ESAL Determination	2	13
9. Enforcement	2	13
10. General Transportation Policy	2	13
11. Interstate/International Vehicle Registration	1	7
12. Geometric Design	1	7
13. Truck Permits	1	7

Table 5. Highway Locations Recommended for WIM Monitoring

A. Rural Highways

Highway Functional Class	Number of Org. Units Recommending
Interstates	7
Principal Arterials	7
Minor Arterials	6
Major Collectors	7
Minor Collectors	5
Local Roads	4

B. Urban Highways and Streets

Interstate	3
Freeways and Expressways	4
Primary Arterials	3
Secondary Arterials	2
Collectors	1
Residential Streets	1

Characteristics of Truck Traffic and Weight Information

Table 3 suggests that truck volumes from vehicle classification counts is the most frequently used or desired information. Gross Vehicle Weight and other axle weight characteristics are required by some organizational units whose work involves the use of such truck weight data. Organizational units like the Bureau of Motor Vehicles and the Permits Section of IDOH Maintenance Division require truck weight information at the time of registration or when oversize/overweight vehicles request for special permits. However, the Department of Revenue requires on-road truck weight information to be able to assess weight-distance characteristics for tax purposes.

Purpose for Using Truck Information

The summary of purposes expressed by the organizational units is presented in Table 4. Specific responses by individual agencies are presented in Appendix A. The primary purpose for using truck weight information is to determine traffic characteristics and growth factors. In addition, traffic safety, pavement management, pavement design were also important. Owing to the use of standard design vehicles in bridge design, truck and axle weight data are considered useful mainly when determining bridge fatigue characteristics. Since weight limits are stipulated in traffic regulations, continuous monitoring of overweight characteristics is required for effective enforcement by the Police.

Location of Truck Weight Monitoring Stations in Indiana

Indiana currently has fifteen weigh stations including two mechanical scales on highways US 6 and US 20. The remaining electronic scales are on Interstates. Appendix B describes the locations of the weigh stations. Two WIM screening scales are also located at two stations on I-94. The Maintenance Division of IDOH has a program for rehabilitating and modernizing the existing scales. Facilities for computer hookup have been provided with some scales but are not being used.

The survey results in Table 5 show that truck weight monitoring should be extended to cover other highway functional classes. A small sample would be desirable on minor collectors and local roads.

Truck Traffic, Truck Weight and WIM Data Collection

Two divisions of IDOH currently collect information on truck traffic volumes and weights. Summaries of the locations and programs for data collection are presented in the following sections for Program Development Division and Division of Research and Training, respectively.

Program Development Division (IDOH)

The Program Development Division (PDD) of IDOH, in cooperation with FHWA conducts a statewide Truck Weight and Vehicle Classification Study in odd numbered years. In even-numbered years, only a Vehicle Classification Study is undertaken. The information collected in the Truck Weight Study is sent to FHWA for processing and the FHWA in turn, provides IDOH with results [4]. The data compiled on truck weight include gross vehicle weight, axle weight, percent trucks overweight, truck classification and number of axles and spacing. W-Tables and Percent Truck information are also prepared. The requirements for truck weight monitoring have been set by FHWA [5]. The 1983-1985 Indiana Traffic Statistics Report [4] has summary information in W-3 tables showing number of loaded and empty trucks for all stations. 18-kip axle weight rates and equivalents for flexible and rigid pavement design are also presented in the report. The locations where truck weight information was collected in 1983 and 1985 are shown in Figure 1. The PDD estimates percentage of trucks from manual traffic classification count data. Table 6 shows the distribution of manual classification count stations from 1979 to 1986. The number of stations set up varied from year to year and different combinations of locations were monitored.

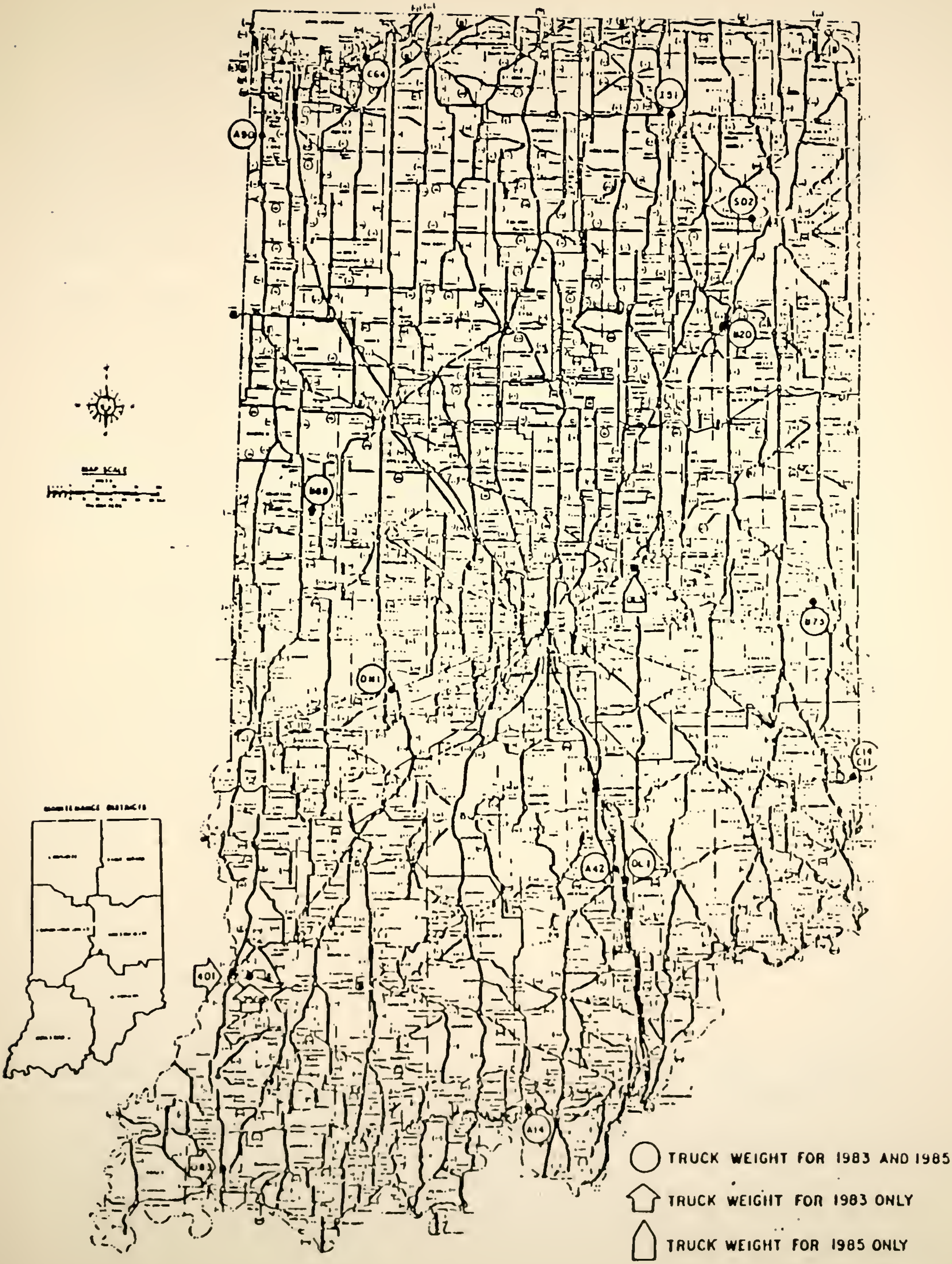

Figure 1. Truck Weight Study Locations - 1983 and 1985.

Table 6. Manual Traffic Classification Count Locations (1979-1983)[1]

Type of Highway	Total Individual Stations Listed	Year/Number of Stations 1979	1980	1981	1983
Rural Interstate	20	8	11	9	11
Rural Primary	46	5	21	10	21
Rural Secondary	15	2	9	2	11
Urban Interstate	21	-	3	1	5
Urban Primary	10	3	3	3	1
Urban Secondary	4	1	3	2	3

[1] Source: Program Development Division, IDOH

Table 6 (Continued). Manual Traffic Classification Count Locations (1984-1986)[1]

Type of Highway[2]	Total Individual Stations Listed	Year/Number of Stations 1984	1985	1986
Rural Interstate	20	10	8	14
Rural Other Primary Arterial	46	9	4	11
Rural Min. Arterial	15	3	2	15
Major Collector		0	3	15
Urban Interstate	21	15	3	18
Urban Prim. Arterial	10	2	1	7
Urban Min. Arterial	4	1	3	5

[1] Source: Program Development Division, IDOH

[2] Based on new classification system.

Between Fall 1985 and Spring 1986, the state continuous stations were modernized using telemetry. The number of permanent stations were increased from 31 to 60. (See Figure 2 and Table 7). The locations were selected using both random sampling and informed judgment. Using telemetry, each site is monitored and data are retrieved from the field units by an office operated central microcomputer that is linked to a telephone line. The microcomputer will also be used for preparing data for editing and storage on a mainframe. The equipment determines traffic volume, vehicle classification, axles, truck lengths and speed depending on the program configuration applied to the field micro-processor counter but not the related weight information.

The PDD believes that undertaking WIM in addition to current programs is possible but depends on the availability of the required resources. However, other IDOH divisions and other state agencies requiring WIM information should provide specifications and be prepared to analyze the data collected.

Division of Research and Training (IDOH) - WIM Pilot Study

The DRT began a pilot WIM data collection program using a portable Golden River Weighman equipment. Thirty-two randomly selected locations were identified and summary

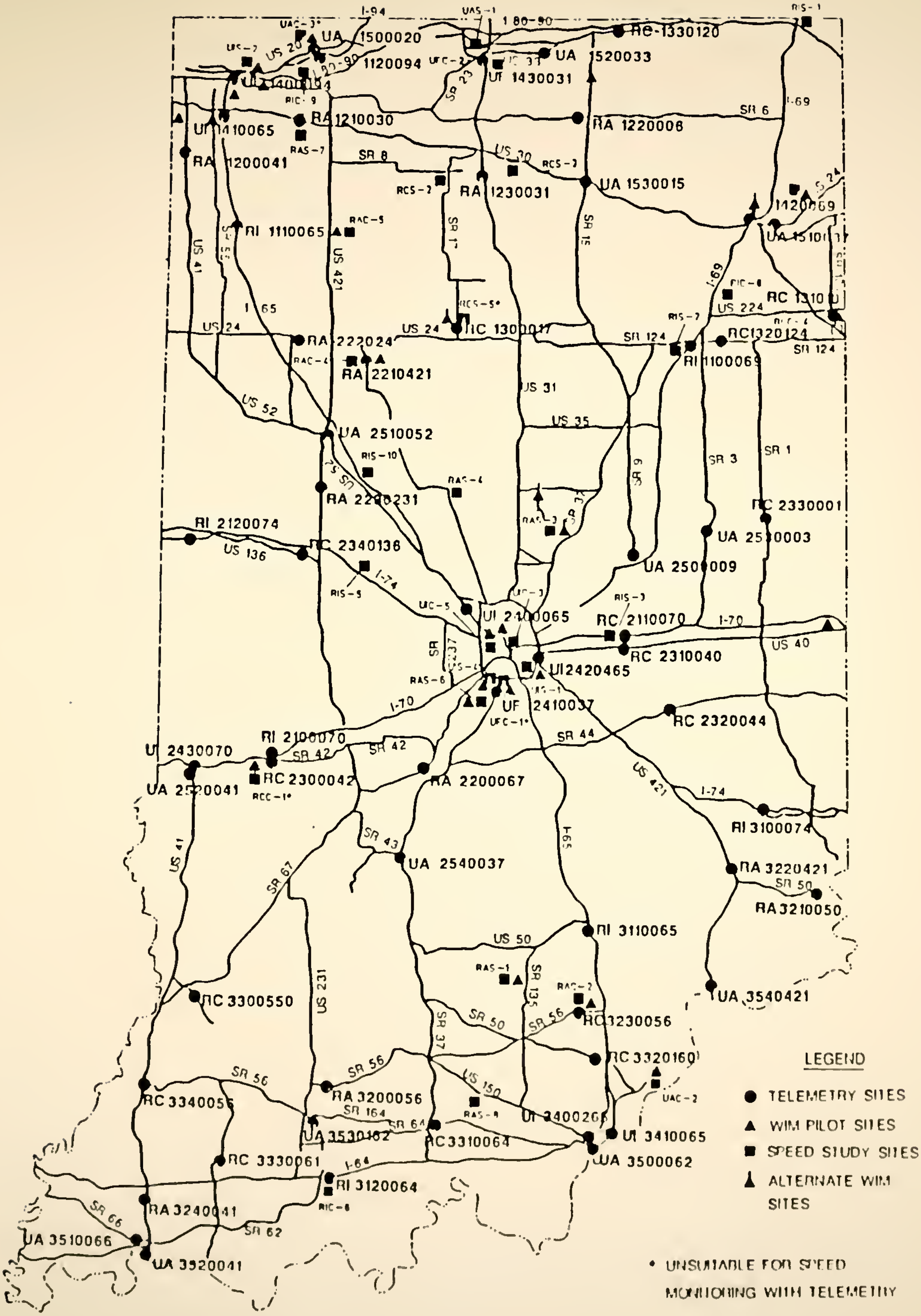

Figure 2. Current Telemetry, Speed Study and WIM Pilot Study Stations. (As of May 1987)

Table 7. Continuous Telemetry Traffic Count Stations

Type of Highway	Number of Stations
Rural Interstate	8
Rural Arterial	14
Rural Collector	16
Urban Interstate	8
Urban Arterial	14
Urban Freeway	2

* Source: Program Development Division, IDOH

information on the distribution by highway functional class is in Table 8. The number of WIM study locations represents the minimum requirements of FHWA. Sites on Rural Interstates were selected near existing weigh stations. The other locations coincided with either the Indiana Speed Study sites or traffic count sites used in the Indiana Cost Allocation Study [6]. The stations sometimes also coincided with telemetering sites as shown in Figure 2.

The DRT experienced problems with the operation of the Golden River portable equipment at sites on reinforced concrete pavements. Steel reinforcement was found to interfere with the performance of the loops during measurements hence, WIM measurements were discontinued from the latter part of the summer of 1986. Golden River Corporation recalled the equipment and has reportedly resolved the problem and undertaken further tests on the equipment. The DRT has received new software for the equipment and is expected to resume field measurements by the middle of May, 1987. If the WIM program is to be implemented successfully, the equipment selected will be important owing to the need to coordinate all aspects of traffic and truck weight data collection.

Enforcement and Trucker Cooperation

Enforcement will continue to be undertaken by the State

Table 8. Pilot WIM Highway Functional Class Groupings

Highway Functional Class	Number of Locations
Rural Interstate	7
Urban Interstate	5
Rural Other Principal Arterial Rural Minor Arterial	5
Rural Major Collector Rural Minor Collector	5
Urban Other Freeway and Expressway Urban Other Principal Arterial	5
Urban Minor Arterial Urban Collector	5

* Source: Division of Research and Training, IDOH.

Police for overweight violations. The Police consider education programs aimed at improving the cooperation of truckers, paramount to effective and successful enforcement. Previous experience of Indiana State Police has demonstrated the importance of such cooperation in the success of safety inspection programs in Indiana [7]. The police endorse any programs seeking to encourage and improve the cooperation of truckers.

The representatives of the IMTA and the American Trucking Association (ATA), when contacted in the presented study, expressed concern about accuracy of truck sampling applied in drawing conclusions from WIM surveys. They endorse the use of WIM data for planning and other engineering purposes. However, if WIM is used for estimating such characteristics as percent of trucks overweight, etc., it was feared that the data accuracy may be suspect. It was further pointed out that the particular software used may greatly influence the accuracy of data and the results of analysis. Hence, due consideration must be given to the methods of signal sampling applied by the equipment used for WIM measurements.

The above sentiments further endorse the importance of ensuring equipment accuracy in extending the use of WIM data for enforcement purposes. In Indiana, the results of the Pilot WIM study program will determine the feasibility of eventual extensive application of WIM technology for truck weight data collection for highway planning and design and for enforcement of regulations.

Summary Survey Conclusions

The following conclusions and recommendations are drawn from the survey results.

1. There exists a definite need for consistent data on truck traffic and weight distribution on Indiana highways for the purpose of planning and design as well as for enforcement.

2. Any new truck weight or WIM monitoring program should complement existing traffic counting program and should cover other highways in addition to Interstates.

3. Since WIM equipment can be used for obtaining truck traffic, speed as well as weight information, further examination is required of the feasibility of combining the WIM monitoring locations with existing traffic volume monitoring locations of the Program Development Division. Sites have been selected independently for the WIM Pilot Study by the Division of Research and Training, IDOH.

4. The results of the WIM Pilot Study should be carefully monitored regarding, particularly, the type and

accuracy of equipment suitable for implementing a continuous WIM program.

5. Appropriate education programs covering various aspects of WIM applications and some of the results of the pilot program, should be given to private truckers in Indiana to ensure some measure of cooperation if WIM is to be used eventually for enforcement purposes.

FHWA Requirements for Traffic and Truck Weight Data

The FHWA has guidelines for state highway traffic monitoring programs including truck weight surveys [5]. Following the general principles in the FHWA guidelines, WIM program in Indiana should be undertaken as part of a coordinated program of traffic counting, vehicle classification, truck weighing and speed monitoring.

A typical Traffic Monitoring Program outlined in the FHWA guidelines is divided into three major elements [5]:

1. Continuous Count element
2. HPMS element, and
3. Special Needs element

The HPMS element consists of four sample subsets.

1. HPMS sample
2. Traffic Volume sample

3. Vehicle Classification sample

4. Truck Weight sample

5. Speed Study sample

Item 5 above is added for program completeness in Indiana. The Indiana Speed Study is currently conducted annually by the Joint Highway Research Project at Purdue University. Some of the sites monitored for speed are included in the sites selected for the Pilot WIM program by DRT (IDOH). Items 1 to 4 of the HPMS element is the direct responsibility of the Program Development Division (PDD) of IDOH.

The FHWA sampling recommendations require a minimum of 90 measurements taken over a 3-year cycle with 1/3 of the sample on the Interstate System. The remaining 60 measurements are to be distributed over the remaining state roads. No roads classified as "local" in the jurisdiction of county highway or city street departments are included in the sample. Table 9 describes the suggested number of FHWA truck weight sample measurements covering two highway stratification levels - Interstates and Other State Highways. Based on the objectives stated for the WIM program in Indiana, the number of locations may be increased in the long-term. After the completion of the WIM Pilot Study by DRT, it would be possible to expand the scope of the existing Truck Data Collection Program in Indiana.

Table 9. Suggested Number of FHWA Sample Measurements

Strata	No. of Measurements (3-year)	Annual Measurements	Expected Precision (%) of 3S2 EAL System Estimates (3-year Cycle)
Interstate	30	10	10 (95)*
Other Roads	60	20	10-20 (95)**

* Sample estimates are expected to be within ±10% of population value with 95% confidence.

** Sample estimates are expected to be ±10 to 20% of population value with 95% confidence.

<u>WIM Data Requirements and Data Collection</u>

An important aspect of truck data collection programs using WIM technology is the types of data likely to be obtained. To date, sample surveys conducted at static permanent weigh stations have obtained data to fulfill requirements for the FHWA Truck Weight Survey (TWS) [5]. With the convenience of WIM technology, it would be expected that the need for on-site interview surveys would be minimized. However, it is not possible to obtain most of the information on specific characteristics of trucks weighed with WIM scales [1]. Table 10 shows the data typically obtained for the TWS.

Interview data on vehicle characteristics cannot be obtained using WIM equipment, however, are considered optional for the FHWA TWS [5]. When Indiana adopts WIM technology to determine truck weight characteristics, such interview data will be required periodically from sample surveys.

Alternately, the Automatic Vehicle Identification System (AVI) using transponders fixed on trucks could be used but they have only recently been tested in Oregon [8]. AVI may also not provide information on load status and commodities carried. The demonstration project that involved 200 trucks operated by 21 trucking firms was

Table 10. Suggested FHWA Truck Weight Study Data Format

A. Identification Data

1. State
2. Functional classification of the highway
3. Station number
4. Direction of travel
5. Year of weighing
6. Month of weighing
7. Date of weighing
8. Hour of weighing
9. Type of vehicle

B. Interview Data (Vehicle Characteristics)

1. Body type
2. Engine type (fuel type)
3. Registered weight
4. Basis of registration
5. Commodity carried
6. Load status

C. Axle Data

1. Individual axle weights
2. Spacings between adjacent axles
3. Sum of all axle weights (total vehicle weight)
4. Sum of all axle spacings (Total wheelbase)

successful. The equipment performed well under the prevailing environmental conditions with a recording rate of about 99.4% of the vehicles passing. Although the AVI equipment only required correct mounting for good performance, it was limited by the maximum range of 34 feet for the antennas that limits its use to locations on two-lane highways. At present, there are no plans to adopt the AVI system in Indiana. The AVI system, nevertheless, is considered an important component in the long-term if WIM technology is to be employed for continuous enforcement purposes. WIM equipment such as the portable Golden River Weighman, in addition, provides information on speed and time of passage and shows if the weights measured comply with the Bridge Gross Weight Formula or not [5].

Adopting WIM will enhance the scope of data collection for vehicle weights and other performance measures while limiting general descriptive information. The FHWA and the IDOH should both agree on the usefulness of the missing information to decide whether additional sample surveys will be required.

Suggested Objectives of Indiana WIM Data Collection Program

Alternatives for WIM program coordination should be developed to satisfy established objectives for the utilization of truck weight information. The following objectives are suggested for the WIM program based on the results of the survey of agencies in Indiana.

The main objectives will be to provide vehicle weight and performance data that will enable:

1. the determination of truck weight and axle weight distribution as well as the calculation of ESALs and growth factors for pavement design and pavement management in Indiana.

2. the determination of truck weight distribution for the review of the vehicle cost allocation distribution formula for Indiana.

3. the assessment of other characteristics of road use such as percent of trucks, traffic growth factors, vehicle speeds to supplement data collection for HPMS and speed surveys.

4. the determination of truck overweight trends to establish suitable enforcement measures or to determine new locations or the need for more detailed weight measurements.

<u>Alternatives for the WIM Program Coordination</u>

The WIM program objectives stated above suggest that responsibility for the WIM program may be assigned to the Program Development Division. With the PDD already collecting planning and traffic information, this step will ensure the needed coordination of the entire program for traffic monitoring, data collection and analysis. It will also avoid unnecessary duplication of data collected using WIM equipment and other traffic equipment.

Another alternative is to assign responsibility for WIM data collection to the Division of Research and Training (DRT) as pertains in the pilot program. The DRT does not, however, feel that the above arrangement is feasible on a permanent basis. The logical choice, therefore, is to assign the WIM data to collection responsibility to the PDD. for WIM requirements.

Coordination of Data Requirements

Although most of the data requirements have been outlined in this report, it is essential that each IDOH Division and other appropriate State agencies reviews its traffic and WIM data needs and coordinate its analysis and reporting with the PDD. The PDD in turn, will define details of tables to be produced from the analysis of weight and other traffic data to the Computer Services Division (IDOH). Each agency will be responsible for any additional analysis required beyond the tables to be prepared from WIM data collected.

Two types of data collection and analysis requirements are expected:

a. Continuous (or frequent) traffic volume and truck weight data collection

b. Periodic or occasional sample data collection and analysis for specific road locations and projects and also at continuous count stations.

Continuous data will be useful for forecasting and for factoring sample information collected for planning purposes. Some of the data collected during periodic or occasional surveys are not routinely collected during continuous surveys. Specific individual vehicle characteristics such as body and engine type and other operational data such as whether trucks were running empty or loaded and the commodity type carried will best be obtained during periodic surveys.

Coordination of Speed, Telemetry and WIM Locations

Speed, Telemetry and WIM monitoring locations are examined for the extent to which they match. Table 11 lists current locations for Telemetry, Speed and WIM Pilot Studies and identifies those locations common to any two or all the

Table 11. Matching of Current Vehicle Monitoring Sites

IDOH DISTRICT	WIM PILOT	SPEED	TELEMETRY
Laporte	WIM	RAC-9	RA2210421
Laporte	WIM	RAC-5	
Laporte		RIC-4	
Laporte		RIC-9	
Laporte	WIM	UFC-2	UF1430031
Laporte		UAC-3	UA1500020
Laporte		RCS-2	
Laporte		RCS-3	
Laporte	WIM	RCS-5	RC1300017
Laporte		UAS-1	
Laporte	WIM	UIS-2	
Laporte		RAS-7	RA1210030
Laporte		*UI-1	
Laporte		*4L-20	
Laporte		*4L-32	
Laporte		*2L-91	
Laporte			UI1400094
Laporte			RI1120094
Laporte			UI1410065
Laporte			RA1200041
Laporte			RI1110065
Laporte			RA2220024
Laporte			RA1230031
Fort Wayne	WIM	RAC-10	
Fort Wayne	WIM	RCC-4	RC1310101
Fort Wayne		RIC-8	
Fort Wayne		RIS-1	
Fort Wayne		RIS-2	
Fort Wayne		*RI-21	
Fort Wayne			RC1330120
Fort Wayne			UA1520033
Fort Wayne			RA1220006
Fort Wayne			UA1530015
Fort Wayne			UI1420069
Fort Wayne			UA1510037
Fort Wayne			RC1320124
Fort Wayne			RI1100069

Table 11 (Continued)

IDOH DISTRICT	WIM PILOT	SPEED	TELEMETRY
Crawfordsville	WIM	RCC-1	RC2300042
Crawfordsville		RAS-4	
Crawfordsville		RAS-6	
Crawfordsville		RIS-5	
Crawfordsville		RIS-10	
Crawfordsville		*4L-17	
Crawfordsville		*2L-79	
Crawfordsville		*RI-34	
Crawfordsville		*2L-54	
Crawfordsville			UA2510052
Crawfordsville			RA2230231
Crawfordsville			RI2120074
Crawfordsville			RC2340136
Crawfordsville			UI2430070
Crawfordsville			UA2520041
Crawfordsville			RI2100070
Greenfield	WIM	UIC-3	UI2400065
Greenfield	WIM	UIC-5	UI2400065
Greenfield	WIM	UFC-1	UF2410037
Greenfield	WIM	RAS-3	
Greenfield		RIS-3	RI2110070
Greenfield		RIS-7	
Greenfield	WIM	UIS-1	UI2420465
Greenfield	WIM	UIS-4	
Greenfield		*4L-21	
Greenfield		*UI-6	
Greenfield		*RI-12	
Greenfield		*2L-18	
Greenfield			UA2530003
Greenfield			RC2330001
Greenfield			UA2500009
Greenfield			RC2310040
Greenfield			RC2320042

Table 11 (Continued)

IDOH DISTRICT	WIM PILOT	SPEED	TELEMETRY
Vincennes		RIC-6	RI3120064
Vincennes			RC3300550
Vincennes			RC3340056
Vincennes			RA3200056
Vincennes			UA3530162
Vincennes			RC3310064
Vincennes			RC3330061
Vincennes			RA3240041
Vincennes			UA3510066
Vincennes			UA3520041
Seymour	WIM	RAC-2	RC3230056
Seymour	WIM	UAC-2	
Seymour	WIM	RAS-1	
Seymour		RAS-8	
Seymour		*RI-6	
Seymour			RA2200067
Seymour			UA2540045
Seymour			RI3100074
Seymour			RA3220421
Seymour			RI3110065
Seymour			RA3210050
Seymour			UA3540421
Seymour			RC3320160
Seymour			UI3400265
Seymour			UI3410065
Seymour			UA3500062

* = Radar speed site

programs. Ten sites in all three programs and seven Speed and WIM pilot study locations either coincide or are close together (Figure 2). Both speed and WIM measurements require sites that are flat, hence, some telemetry locations may not be suitable for speed monitoring. In general, wherever speed monitoring locations and telemetry sites coincide, speed information can be obtained from telemetry data. Similarly, WIM can be used to obtain speed information whenever speed and WIM sites coincide. In each case, provision should be made for instrument calibration. For electronic hook-up to the telemetry system by either WIM or speed measuring equipment, care is required to ensure continuity of information obtained by telemetry. The technical aspects of this will be investigated further.

As part of a continuous weighing program, it is desirable that WIM data be collected at or near the telemetry sites for comparative analysis of traffic and weight information. Suitable sites for WIM can be selected from current locations after field inspection. All sites identified above could be in the 90 locations monitored for FHWA. The locations near current permanent weigh stations are automatically included as has been done for the WIM Pilot Study. The remaining sections can be randomly selected to make up the 90 locations.

Unlike the telemetry traffic information that is collected continuously, WIM data can be initially collected 4 times a year in each season. The frequency can be reduced if consistent repeating patterns are identified. Sample weighings can be undertaken at additional locations as required for completeness of the program.

Future Work in the Study

The remainder of the project will consist of the following activities:

1. Follow up of the WIM Pilot Program and identification of problems with data collection and analysis as well as monitoring of results of the analysis.

2. Identification of additional locations for WIM monitoring in collaboration with DRT and PDD of IDOH.

3. Definition of needs and costing of manpower and equipment requirements for a WIM program.

4. Preparation of Draft Final Report.

Acknowledgment

The assistance of David Cochran in furnishing information on speed monitoring locations and their matching with telemetering sites is gratefully acknowledged.

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7. "Trucking Image in Indiana Enhanced by Safety Program." <u>In Transport Topics</u>. A Newspaper of the Trucking Industry No. 2644, Alexandria, VA., April 14, 1986.

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Agency (Officials)	Data Use Frequency	Type of Data Used or Needed	Purpose of Truck Weight and Traffic Data Use	Recommended Road Locations
1. Department of Revenue (James W. Poe,) (Administrator, Special Tax Div.) (and Terri L. Soult) (Administrative Assistant)	As Needed	Gross Vehicle Weight Vehicle/Truck Classification	Revenue Estimation (Weight-Distance Tax) (under consideration)	—
2. Metropolitan Planning Organization (Sweson Yang)	As Needed	Vehicle/Truck Classification Passenger Car Equivalencies * Urban Goods Movement *	Truck Routing	—
3. Indianapolis DOT (Street Dept.) (Bob Schoett)	Routinely	Gross Vehicle Weight Axle Weight Distribution Vehicle/Truck Classification Number of Axles and Spacing Annual Truck Weight Trends	Pavement Management Pavement Design Bridge Design Traffic Charateristics and Growth Factors	Interstates Freeways and Exp. Principal Arterials Secondary Artls. Collectors Res. Streets
4. Bureau of Motor Vehicles Assist. Directors Jane Morrical (Cash Audit) Cindy Railey (Special Sales Div) Joy Prabst (IRP) Bobbi Canada (Titles, Registration & Excise)	Routinely	Gross Vehicle Weight Unladen Veh. Weight * Purchase Date/Price * Number of Axles *	Interstate/International Vehicle Registration (IRP)	—
5. Public Service Commision Claudia Earls (Director, Transportation)	Not Used at all.	—	Main Interest is in enforcement employing 19 state troopers. Grants carriers authority to operate.	--

* Information not currently used but may be required in the future

Agency (Officials)	Data Use Frequency	Type of Data Used/Needed or collected	Purpose of Truck Weight Data Use	Recommended Road Locations
6. Transportation Planning Office (Mike Rampley)	As Needed	Gross Vehicle Weight Axle Weight Distribution Vehicle/Truck Classification Number of Axles Anuual Truck Weight Trends Commodity Flows (Periodic) Trucks carrying less than capacity (45 ft. vs. 40 ft. loaders on rail) * Determination of heavy truck corridors (new route for Michigan trains) *	Revenue Estimation General Transportation Policy. Traffic Charateristics and Growth Factors Determination of potential toll routes. Investigation of effects of route diversions.	Interstates Principal Arterials Minor Arterials. Major Collectors Small Sample on Minor Collectors and Local Roads.
7. Indiana State Police (Lt. Russel Wolfe) (Sgt. K. Poe)	Routinely	Gross Vehicle Weight Axle Weight Distribution Vehicle/Truck Classification Percent Trucks Overweight Truck volumes bypassing Weigh Stations *	Enforcement and Compliance Traffic Safety and Regulations Bridge Formula Compliance	All Rural Road Locations

* Information not currently used but may be required in the future

Agency (Officials)	Data Use Frequency	Type of Data Used/Needed or collected	Purpose of Truck Weight Data Use	Recommended Road Locations
<u>I. D. O. H.</u>				
8. <u>Planning and Budget Division</u> (Dennis Faulkenberg)	Not Used now but in the future	Gross Vehicle Weight Vehicle/Truck Volumes Anuual Truck Weight Trends	Traffic Charateristics and Growth Factors Revenue Estimation General Transportation Policy.	—
9. <u>Program Development Division</u> (Don Houterloot) (John Nagle) (Kirk Mangold)	Routinely Collects Traffic data for other divisional needs	Gross Vehicle Weight Axle Weight Distribution Percent Trucks Overweight Vehicle/Truck Classification (Percent Trucks) Number of Axles and Spacing	Traffic Charateristics and Growth Factors General Transportation Policy and Revenue Estimation as required.	Interstates Principal Arterials Minor Arterials. Major Collectors
10. <u>Research and Training Division</u> (Keith Kercher and) (Robert Shanteau)	As Needed for Research and Testing WIM equipment	Gross Vehicle Weight Axle Weight Distribution Vehicle/Truck Classification Number of Axles and Spacing Speed and Time of passage ESAL Bridge Formula Compliance Axle Weight Distribution by functional class and vehicle type *.	Traffic Charateristics and Growth Factors Traffic Safety (Skid Resistance). <u>Marginally</u> for Pavement Management Pavement Design and Bridge Design	<u>Rural</u> Interstates (High Accuracy) Principal Arterials (High Accuracy) Minor Arterials. (Moderate Accuracy) Major Collectors (Low Accuracy) Minor Collectors (Low Accuracy) <u>Urban</u> Interstates Freeways Principal Arterials

* Information not currently used but may be required in the future

Agency (Officials)	Data Use Frequency	Type of Data Used/Needed or Collected	Purpose of Truck Weight Data Use	Recommended Road Locations
I.D.O.H.				
11. Road Design Division (Eugene Mason) Design Services Engineer	Routinely	Gross Vehicle Weight Axle Weight Distribution Percentage Trucks (Single and Multiple Units) Axle Weight by Highway lane * Anuual Truck Weight Trends *	Pavement Design Traffic Charateristics and Growth Factors General Transportation Policy.	Rural All functional classes for greater coverage Urban Interstates and Freeways
12. Bridge Design Division (Jack White) Standards Engineer	Not Used much	Vehicle/Truck Volumes	Truck weights may be considered in fatigue design	
13. Maintenance Division (Carl Kramer) Maintenance Operations Engineer (Keith Saville) Buildings and Grounds Engineer (Bob Cales) Engineer in Charge of Permits	Not Used Except for Permits	Gross Vehicle Weight furnished by operators for permits	Permits for oversize and overweight vehicles or indivisible loads Maintenance of weigh station facilities with contract maintenance of electrical and mechanical equipment	--
14. Traffic Engineering Division (Carl Tuttle) Traffic Evaluation Engineer	Not used but may be useful later	Vehicle/Truck Classification (Percentage Trucks) Gross Vehicle Weight Number of Axles and Spacing * Truck Lengths *	Determination of Turning Radius and Lane Widths	Interstates Principal Arterials Major Collectors

* Information not currently used but may be required in the future

Agency (Officials)	Data Use Frequency	Type of Data Used/Needed or collected	Purpose of Truck Traffic and Weight Data Use	Recommended Road Locations
I.D.O.H. 15. District Offices (Richard Howden) Deputy Director, Districts (Charles Hendricks) District Engineer, La Porte District (John Perryman) District Maintenance Operations Engineer La Porte District (J. G. Schmidt) District Traffic Engineer, La Porte	Not Used but may be useful	Gross Vehicle Weight Axle Weight Distribution Vehicle/Truck Volumes	Determination of Turning Radius and Lane Widths Design at Head Office	Interstates Principal Arterials Major Collectors

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WEIGH STATIONS PROJECT NUMBERS

Project No.	Road	Section	Subdistrict	Location
Crawfordsville District				
W-102 (2)	I-74 (E) (1-1985)	23	Veedersburg	2.73 mi. West of S.R. 341
Ft. Wayne District				
W-201 (1)	US 6 (M)	57	Goshen	0.88 mi. West of U.S. 33
W-202 (2)	I-69 (E) (NB-2-1983) (SB-3-1986)	35 Under Contract	Bluffton	2.5 mi. Northeast of S.R. 5
Greenfield District				
W-304 (2)	I-70 (E) (3-1982)	89	Centerville	1.0 mi. West of U.S. 35
LaPorte District				
W-402 (1)	US 20 (M)	64	Valparaiso	1.4 mi. East of S.R. 49
W-406 (2)	I-65 (E) (1-1984)	45	Gary	1.0 mi. North of S.R. 2
W-407 (2)	I-94 (E) (1-19)	64	Valparaiso	5.7 mi. West of U.S. 421
Seymour District				
W-502 (2)	I-65 (E) (3-1983)	36	Seymour	1.2 mi. North of U.S. 50
W-503 (1)	I-74 (E) (3-1986)	15 Under Contract	Aurora	0.5 mi. West of State Line
Vincennes District				

Code: (1-1986) 1st number is manufacturer
2nd number is year constructed
(1) or (2) Number of Stations
(E) Electronic Scale
(M) Mechanical Scale

1 = Streeter Richardson
2 = Masstron
3 = Weigh Tronix

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